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**OPTICAL MODELING APPARATUS**

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(54) [Title of Invention] Optical modeling apparatus

(57) [Abstract]

[Object]

To prevent changes in the liquid resin surface level and to obtain a smooth free surface using a simple mechanism.

[Constitution]

An optical modeling apparatus comprises: means for irradiating a surface layer portion of a photosetting liquid resin (3) contained in a processing tank (7) with a UV laser beam based on cross-sectional shape data obtained by slicing a three-dimensional modeled object (2) into layers; means for introducing a next liquid layer onto a solidified layer alternately with irradiation with the UV laser beam; and a squeegee (4) for leveling the free surface (3a), the apparatus forming a three-dimensional modeled object by solidifying liquid resin one layer at a time on the top of a base plate, the aforementioned squeegee (4) being freely movable along the free surface (3a) of the aforementioned liquid resin (3) so that the end face of the squeegee enters the aforementioned liquid resin (3) or coincide with the aforementioned free surface (3a) so that the three-dimensional modeled object (2) is formed in the zone where the aforementioned end face and the aforementioned free surface (3a) coincide.

#### Claims

1. An optical modeling apparatus comprising: means for irradiating a surface layer portion of a photosetting liquid resin (3) contained in a processing tank (7) with a UV laser beam based on cross-sectional shape data obtained by slicing a three-dimensional modeled object (2) into layers; means for introducing a next liquid layer onto a solidified layer alternately with irradiation with the UV laser beam; and a squeegee (4) for leveling the free surface (3a), said apparatus forming a three-dimensional modeled object by solidifying liquid resin one layer at a time on the top of a base plate, the aforementioned squeegee (4) being freely movable along the free surface (3a) of the aforementioned liquid resin (3) so that the end face of the squeegee enters the aforementioned liquid resin (3) or coincide with the aforementioned free surface (3a) so that said three-dimensional modeled object (2) is formed in the zone where the aforementioned end face and the aforementioned free surface (3a) coincide.

2. The optical modeling apparatus according to claim 1, wherein rails guiding the end face of the squeegee are arranged in parallel to the free surface of the liquid resin in the zone where said end face of the squeegee and the free surface coincide.

3. The optical modeling apparatus according to claim 2, wherein said rails are provided with a mechanism permitting vertical position adjustment.

#### Detailed Description of the Invention

[0001]

[Field of Industrial Application]

The present invention relates to an optical modeling apparatus for forming three-dimensional modeled objects of arbitrary shapes by solidifying liquid resin layer by layer, and, more particularly, to an optical modeling apparatus capable of shortening the time and improving the accuracy of modeling of three-dimensional modeled objects by means of efficiently supplying liquid resin for lamination.

[0002]

[Prior Art]

FIG. 9 is a schematic block diagram showing a prior-art optical modeling apparatus. In this drawing, reference numeral (7) designates a processing tank containing liquid resin (3) with a base plate (1) that can be freely raised or lowered by means of a drive mechanism (8). Located above the processing tank (7) is a scanning unit (11) that guides a laser beam (10), resulting from the excitation of a laser beam excitation unit (9), across the surface of the liquid resin (3) in the processing tank (7) by scanning it in accordance with slice data obtained by slicing the three-dimensional modeled object (2). Below the scanning unit (11), there is provided a lens (12) focusing the laser beam (14) on the liquid resin surface (3a).

[0003]

The processing tank (7) contains an overflow surface (7a) that always maintains the surface (3a) of the liquid resin (3) at a predetermined level. Furthermore, the processing tank (7) is provided with an auxiliary tank (16) that ensures overflow of the liquid resin (3) across the overflow surface (7a). A pump (15) is used for re-circulation of the liquid resin (3) by feeding the liquid resin (3) from the auxiliary tank (16) back to the processing tank (7). In addition, there is provided a squeegee (4) which assists in mechanically smoothing out the liquid resin surface (3a).

[0004]

A CAD data processing unit (13) is connected to the drive unit (8) and the scanning unit (11) and produces base plate drive data and scanning data from the cross-sectional shape data for the three-dimensional modeled object (2).

[0005]

The prior-art optical modeling apparatus having the above-described construction operates in the manner described below. The base plate (1) is positioned below the liquid resin surface (3a), and scanning with laser beam (10) is carried out using the scanning unit (11) based on slice data produced by the CAD data processing unit (13), focusing the scanning laser beam (14) on the liquid resin surface (3a) and solidifying the liquid resin (3) on the base plate (1) in accordance with the cross-sectional shape of the three-dimensional modeled object.

[0006]

After the solidification of the resin is completed for the cross-section of the lowermost layer, a second solidified layer, as well as subsequent layers, are then formed by the method described hereinbelow. The liquid resin (3) overflowing across the overflow surface (7a) and filling in the auxiliary tank (16) is again fed to lowermost part of the processing tank (7) by the pump (15). The scanning with a laser beam (14) is then performed based on the slice data, and a solidified resin layer of a different cross-sectional shape is formed on top of the aforementioned resin layer solidified on the base plate (1). If laminar buildup and scanning is successively repeated in the above-described manner, a three-dimensional modeled object (2) can be formed that has the desired cross-sectional shape.

[0007]

Detailed explanations regarding the method used for liquid resin lamination are provided next. For example, the method described in Japanese Unexamined Patent Publication No. Sho 63[1988]-141724 is known as a method used for the lamination of liquid resin. This method is explained herein by referring to FIG. 9. Herein, the base plate (1) is lowered in the direction of the bottom of the processing tank (7) by the drive unit (8) so that liquid resin (3) covers the top of the three-dimensional modeled object (2). Then, based on the drive data, the base plate (1) is raised again and stopped at a position which is, in accordance with the slice data, one layer lower than the position where resin was solidified previously. Because the resin liquid (3) used at such time is a liquid resin of a relatively high viscosity, such as modified polyurethane methacrylate, epoxy acrylate, etc., the surface liquid resin (3) on top of the three-dimensional modeled object (2) is raised above the liquid resin surface (2a) of the rest portion. In order to eliminate the raised structure, the squeegee (4), in response to squeegee control commands from the CAD data processing unit (13), sweeps the liquid resin surface (3a).

[0008]

Furthermore, Japanese Unexamined Patent Publication No. Hei 06[1994]-285998 describes a method wherein, as distinguished from the above-described lamination method, a modeling tank has an external tank and an inner liquid layer [sic; *typo instead of "inner liquid tank" – trans.*] [I think they did mean 'inner tank' since they go on to describe the wall/bellows of this tank] formed inside the external tank and having walls, made up of bellows whose periphery can be extended and shrunk, and a base, the bottom of which can be moved in the vertical direction. In this process, the photosetting resin is fed from the external tank onto the base inside the inner liquid layer [sic; *typo instead of "inner liquid tank" – trans.*] for lamination.

[0009]

[Problems the Invention Seeks to Overcome]

However, the above-described prior art had the following problems. Detailed explanations are provided hereinbelow by referring to FIG. 10, which is a side view showing the principal portion of the prior-art optical modeling apparatus. In the lamination method described in Japanese Unexamined Patent Publication No. Sho 63[1988]-141724, the modeling process requires a significant time for steps of lowering and raising inherent in the structure of the system, in which the base plate (1) has to be lowered to a region in the vicinity of the bottom portion of the processing tank (7) and then raised again. In addition, in accordance with this invention, once the base plate (1) is deeply submerged, a flow of liquid resin (3), shown with arrow (a) in FIG. 10, is generated, so that liquid resin (3) flows over the top of the three-dimensional modeled object (2) and, at the same time, overflows across the overflow surface (7a), with a greater than usual amount of liquid resin (3) flowing into the auxiliary tank (16). Because the supply of liquid resin (3) into processing tank (7) is constant at all times, the level of liquid resin surface (3a) changes. Since the degree of this change varies in proportion to the volume etc. of the base plate (1) and three-dimensional modeled object (2) immersed in the liquid resin (3) inside the processing tank (7), the level of the liquid resin surface (3a) varies depending on the position of the base plate (1). When the level of the liquid resin surface (3a) varies, naturally, the thickness of a single layer based on slice data becomes unstable, resulting in unsatisfactory accuracy and layer peeling defects.

[0010]

Another disadvantage of the lamination method of Japanese Unexamined Patent Publication No. Hei 06[1994]-285998 in comparison with the method in which lamination is effected by the raising and lowering of the base plate (1) is that the entire apparatus has to be larger to the extent that the inner liquid layer [sic; *typo, "inner liquid tank" – trans.*] could be immersed in the external tank.

[0011]

The present invention is aimed at the solution of the above-described prior-art problems and provides an optical modeling apparatus which, using a simple mechanism, is capable of preventing changes in the liquid resin surface level thereby imparting a smooth free surface.

[0012]

[Means for Overcoming the Problems]

In order to attain the above-described object, the optical modeling apparatus of the present invention is constructed as follows. According to the embodiment of claim 1, an optical modeling apparatus comprises; means for irradiating a surface layer portion of a photosetting liquid resin (3) contained in a processing tank (7) with a UV laser beam based on cross-sectional shape data obtained by slicing a three-dimensional modeled object (2) into layers; means for introducing a next liquid layer onto a solidified layer alternately with irradiation with the UV laser beam; and a squeegee (4) for leveling the free surface (3a), said apparatus forming a three-dimensional modeled object by solidifying liquid resin one layer at a time on the top of a base plate, the aforementioned squeegee (4) being freely movable along the free surface (3a) of the aforementioned liquid resin (3) so that the end face of the squeegee enters the aforementioned liquid resin (3) or coincide with the aforementioned free surface (3a) so that said three-dimensional modeled object (2) is formed in the zone where the aforementioned end face and the aforementioned free surface (3a) coincide.

[0013]

According to the embodiment of claim 2, the construction of claim 1 is provided with rails guiding the end face of the squeegee in parallel to the free surface of the liquid resin in the zone where the aforementioned end face of the squeegee and the free surface coincide. In this case, the parallel rails should be arranged in a position close to the free surface of the liquid resin, in other words, in a direction normal to [*sic*; - *trans*.] the direction in which the squeegee moves along in the processing tank, and the top face of the rails should be aligned with the free surface.

[0014]

Furthermore, according to the embodiment of claim 3, the construction of claim 2 has the aforementioned rails provided with a mechanism permitting vertical position adjustment. In this case, the vertical position adjustment mechanism should be arranged in two positions next to both ends of the rails so as to permit adjustment based on of the level of the free surface and the degree of parallelism.

[0015]

[Action]

In the embodiment of claim 1, large tides of liquid resin are generated in the zone where the end face of the squeegee enters the liquid resin. In the subsequent zone, the surface of the liquid resin is subjected to sweeping. In other words, the leveling of liquid resin surface and the liquid layer of the liquid resin can be carried out by the sweeping action of the squeegee alone, resulting in a reduction of the liquid resin lamination time. In addition, when the raising and lowering of the base plate and the three-dimensional modeled object is kept regulated, this results in a stable liquid resin surface, improved accuracy, and reduced defects on the three-dimensional modeled object.

[0016]

In the embodiment of claim 2, in the initial zone of the operation of the squeegee, where there are no rails, the end face of the squeegee enters the liquid resin. In the subsequent zone, where rails are installed, the leveling of the free surface is possible.

[0017]

In the embodiment of claim 3, along with the vertical position adjustment mechanism for the rails, the degree of their parallelism to the free surface can be also adjusted by providing vertical adjustment on the rails, for example, in two positions next to both ends of the aforementioned rails. In this manner, quick adjustments can be made depending on changes in the level of the free surface, etc.

[0018]

[Practical Embodiments]

Practical embodiments of the optical modeling apparatus of the present invention are explained hereinbelow by referring to the attached drawings. In addition, because the present invention is concerned with a method of liquid resin lamination in an optical modeling apparatus, other principles of the optical modeling apparatus as well as the construction of the apparatus are the same as those described in prior-art specifications. Thus, in the embodiments hereinbelow, explanations regarding the principles of the optical modeling apparatus as well as the construction of the apparatus are omitted, and explanations are provided only with regard to the method of liquid resin lamination. In addition, the same reference numerals are assigned to the same constituent parts as in FIG. 9.

[0019]

[Practical Embodiment 1]

Practical Embodiment 1 of the present invention is explained by referring to FIG. 1 - FIG. 6. FIG. 1 is a three-dimensional view showing the processing tank portion of the optical modeling apparatus used in the present embodiment (the motor, which will be explained below, is not shown). FIG. 2 is a side view that shows a cross-section of the processing tank for the purpose of explaining the motion of the squeegee in the processing tank in FIG. 1. FIG. 3 and FIG. 4 are, respectively, a three-dimensional view and a front view of the principal portion used to explain the mechanism, in which the squeegee is driven relative to the processing tank. FIG. 5 and FIG. 6 are explanatory diagrams showing the operation of the squeegee.

[0020]

In FIG. 1, the squeegee (4), that can be freely moved in the direction of the arrow across the top of the processing tank (7), has a squeegee main body (4a), which has a U-shaped form produced by curving both end sections of the longitudinal portion so that it sits astride the top of the processing tank (7), and a squeegee sweeping section (4b), which is arranged on the bottom face of the longitudinal portion of the main body (4a).

[0021]

The squeegee main body (4a) is arranged so that its longitudinal portion is positioned above the processing tank (7), and both end sections thereof are positioned on the outside surface of the processing tank (7), with the end faces of the end sections, as shown in FIG. 1 and FIG. 3, having inclined faces (20) inclined with respect to the longitudinal portion (horizontal portion) of the main body (4a). In addition, reversing plates (21), which have inclined faces (22) formed on the underside thereof and inclined oppositely with respect to the aforementioned inclined faces (20), are attached to the respective inner faces (the sides of the processing tank (7)) of the U-shaped end sections of the main body (4a).

[0022]

Furthermore, as shown in FIG. 1, FIG. 3, and FIG. 4, an L-shaped guide plate (23) is attached to the inner face (the side of the processing tank (7)) of one of the aforementioned reversing plates (21) provided in the U-shaped end sections of the main body (4a). A motor (24) is attached to the side of the aforementioned end section of the main body (4a), where the guide plate (23) is located. The drive shaft (24a) of the motor (24), as shown in FIG. 4, passes through the end section of the main body (4a), the reversing plate (21), and the guide plate (23),



with a pinion (25) attached to its tip. The pinion (25) is constructed so that it engages with a rack (26) attached to the outside surface of the processing tank (7), and the bottom face of the rack (26) is in sliding contact with the aforementioned L-shaped guide plate (23). Thus, as a result of normal and reverse rotation of the motor (24), the squeegee (4) performs forward or backward motion in the direction indicated by arrow ( $\square$ ) shown in FIG. 1.

[0023]

In addition, the inner face of the reversing plate (21) provided in the other U-shaped end section of the main body (4a) may be placed in direct sliding contact with the outside surface of the processing tank (7). Otherwise, in the same manner as in the case of the above-described other end section, there may be provided a guide plate (not shown) in sliding contact with a rack (not shown) attached to the outside surface (not shown) of the processing tank (7).

[0024]

On the other hand, as shown in FIG. 2 and FIG. 4, the aforementioned squeegee sweeping section (4b), which is located on the bottom face of the longitudinal portion (horizontal portion) of the main body (4a), is rockingly supported by respective support rods (27) installed in a horizontal direction on the inner faces of both end sections of the aforementioned main body (4a), and, at the same time, the sweeping section (4b) is urged with a spring (28) (see FIG. 2) attached to the bottom of the main body (4a).

[0025]

Next, explanations are provided regarding the processing tank (7) containing the liquid resin (3). In FIG. 1, guiding rails (17), which are in contact with the end face of the squeegee sweeping section (4b), are installed on both sides on the inner surface of the processing tank (7). The top faces (17a) of the rails (17) are adjusted to be at the same level as the liquid resin surface (3a).

[0026]

In addition, in FIG. 1, as described above, racks (26) are attached to the outside surface of the processing tank (7), and first stoppers (19) and second stoppers (18) are arranged at the respective end sections of the racks (26). The first and second stoppers (19, 18) are provided, respectively, on opposite outside surfaces of the processing tank (7), with the first stoppers (19) and second stoppers (18) being arranged in respective identical positions. The first stoppers (19) are provided in a position (at a level), in which they can make contact with the inclined faces (20) of the end sections of the aforementioned squeegee main body (4a), and the second stoppers (18) are provided in a position (at a level), in which they can make contact with inclined faces (22) of the reversing plates (21).

attached to the inner faces of the end sections of the squeegee main body (4a). (Therefore, the level of the first stoppers (19) and second stoppers (18) on the sides of the processing tank (7) are different.) Furthermore, as shown in FIG. 2, the locations of the first and second stoppers (19, 18), in which they come in contact with the aforementioned inclined faces (20, 21), are higher than the liquid resin surface (3a).

[0027]

Next, explanations are provided regarding the state, in which the squeegee (4) is set in motion relative to the processing tank (7). In the squeegee (4) shown in FIG. 1, the inclined faces (20) of its main body (4a) are in a state of sliding contact with the top face of the first stopper (19). In this state, the pinion (25) is rotated, driven by the motor (24) shown in FIG. 3 and FIG. 4. The squeegee 4 travels in the direction of arrow (A) in FIG. 2 towards the second stopper (18) by engaging with the rack (26). At such time, the motion is directed from position D towards position C shown in FIG. 2. With the inclined faces (20) of the main body (4a) being in a state of sliding contact with the top face of the first stopper (19), the tip of the sweeping section (4b), urged by the spring (28), enters the liquid resin (3). Next, as a result of the travel of the main body (4a), the tip of the sweeping section (4b), along with being placed on the top face (17a) of the rails (17), is subjected to pressure by the spring (28), which forces it to be at the same level as the top face (17a) of the rails (17), in other words, the same level as the liquid resin surface (3a). Accordingly, the tip of the sweeping section (4b) is caused to perform a sweeping motion in the zone B towards position C.

[0028]

Subsequently, when the sweeping section (4b) reaches the final point of zone B, the liquid resin surface (3a) has been leveled and the resin layer of the desired shape is subjected to solidification. When the resin is completely solidified, the drive unit (8) stops the base plate (1) at a position lower than the top face (17a) of the rails (17) by a single layer of the three-dimensional modeled object (2). Then, a predetermined amount of liquid resin is supplied to the processing tank (7) by a pump (not shown).

[0029]

Subsequently, the U-shaped main body (4a) changes its direction as the inclined faces (22) of the reversing plates (21) move in contact with the second stoppers (18) when they are directed towards position C. In other words, as shown in FIG. 5, while the squeegee (4) is in motion in the direction of the arrow, the inclined faces (22) of the reversing plates (21) come in contact with the second stoppers (18). Furthermore, while the squeegee (4) is in motion, the direction in which the squeegee main body (4a) is inclined is changed with the inclined faces (22) of the reversing plates (21) coming in sliding contact with the top face of the second

stoppers (18). In position C, as shown in FIG. 2, the sweeping section (4b) is urged by the spring (28). However, because of the above-mentioned change in the inclination of the squeegee main body (4a), the tip of the sweeping section (4b) is withdrawn from the free surface.

[0030]

Next, as a result of reverse rotation of the motor (24), the squeegee (4) moves in the opposite direction, in other words, in the direction of arrow (二) shown in FIG. 2, the state of the main body (4a) and the reversing plates (21) at such time being as shown in FIG. 6. Then, because the inclined faces (20) of the squeegee main body (4a) move in contact with the first stoppers (19) when the squeegee (4) passes through zone B and reaches zone A, as shown in FIG. 6, the direction in which the main body (4a) is inclined is changed. While the inclined faces (20) come in sliding contact with the top face of the first stoppers (19), the tip of the sweeping section (4b) enters the liquid resin.

[0031]

In this state, the squeegee (4) moves in the direction of arrow (ノ) of FIG. 2, and, when the squeegee sweeping section (4b) moves through zone A, relatively large tides (3b) are formed on the liquid resin surface (3a) by the squeegee sweeping section (4b). After that, when the squeegee (4) moves through zone B, the position of the squeegee sweeping section (4b) is determined by the top face (17a) of the rails (17), the tides (3b) formed in zone A are leveled, and the gap between the top face of the three-dimensional modeled object (2) on the base plate (1) and the liquid resin surface (3a) is made uniform, in other words, the thickness of the liquid resin (3) forming a layer on top of the three-dimensional modeled object (2) is made uniform. When the squeegee (4) arrives in point C, the orientation of the squeegee (4) is changed by the first stoppers (19) and it comes to a halt.

[0032]

The sweeping action of the squeegee (4) in the present embodiment makes it possible to carry out the leveling of the liquid resin surface (3a) and the laminar buildup of liquid resin (3) on the top of the three-dimensional modeled object (2), as well as to keep the raising and lowering of the base plate (1) to a minimum, along with shortening of the time required for the sculpting of the three-dimensional modeled object (2). Thus, it becomes possible to suppress fluctuations in the liquid resin surface level (3a) and to form highly accurate three-dimensional modeled objects (2).

[0033]

[Practical Embodiment 2]

Embodiment 2 of the present invention is explained next by referring to FIG. 7. FIG. 7 is a side view showing the principal portion of the optical modeling apparatus of the present embodiment. The present embodiment is constructed by providing an adjustment mechanism for the degree of parallelization and vertical position on the rails (17), which determines the position of the tip of the of the squeegee sweeping section (4b) in a compulsory manner. In other words, it is constructed by securing supports (30) to certain positions on the inner surface of the processing tank (7) that correspond to locations underneath both ends of the rail (17) in the longitudinal direction thereof, and arranging the rail (17) on the supports (30) using screws (31), so that the above-mentioned adjustment of the rails (17) is carried out by the rotation of the screws (31). Otherwise, the construction is the same as in Embodiment 1, and explanations concerning it are omitted.

[0034]

Because the present embodiment is adapted to permit adjustment of the level and degree of parallelization of the rails (17) in a straightforward manner, even if changes occur in the liquid resin surface level or the end face of the squeegee for any reason, sculpting can be carried out under the best possible conditions by quickly adjusting the position of the rails.

[0035]

[Practical Embodiment 3]

Practical Embodiment 3 of the present invention is explained next by referring to FIG. 8. FIG. 8 is a perspective view showing the principal portion of the optical modeling apparatus of the present embodiment. Instead of the long rail (17) provided in Embodiment 1, the present embodiment is constructed by arranging several blocks (32) so as to form the aforementioned long rail by linking a plurality of short rails. The blocks (32) are held by magnetic force on a support (33) possessing magnetic properties and secured to the inner surface of the processing tank (7), and can be attached and detached therefrom. Otherwise, the construction is the same as in Embodiment [sic; no embodiment number - trans.], and explanations concerning it are omitted.

[0036]

Because in the present embodiment the zone where the tip of the squeegee (4) enters the liquid resin (3) (zone A in FIG. 2) and the zone where the liquid resin surface (3a) is leveled (zone B in FIG. 2) can be freely determined by the attachment and detachment of the respective blocks (32), the amount and level of the resin used for lamination can be adjusted, and more efficient fabrication of optically modeled objects without lamination defects is made possible.

[0037]

In order to accomplish the above-described objects, the present invention can be also constructed as shown hereinbelow. In the zone where the aforementioned squeegee end face and the free surface coincide, the rails, which guide the squeegee end face and are installed in parallel to the free surface of the liquid resin, can be constructed out of several blocks that can be attached and detached. Based on the above-described construction, the zone where the squeegee end face enters the resin and the zone where it coincides with the free surface can be adjusted arbitrarily.

[0038]

In addition, the apparatus may be constructed by providing the aforementioned several blocks so that they can be detached and attached using magnetic force to a support secured to the processing tank (7). Based on the above-described construction, the attachment and detachment of the blocks forming the rails can be carried out quickly.

[0039]

[Effects of the Invention]

As explained above, the optical modeling apparatus of the present invention permits the laminar buildup of the liquid resin and the leveling of the liquid resin surface to be carried out at the same time because, when the liquid resin surface is swept by the squeegee, it passes through a zone where the tip of the squeegee enters the liquid resin, and then reaches a zone where it moves across the liquid resin surface. Thus, laminar buildup of liquid resin based on the raising and lowering of the base plate is curtailed, resulting in a shortening of the modeling time. In addition, because the circulation of the liquid resin becomes well-regulated by keeping the raising and lowering of the base plate to a minimum, the level of the liquid resin surface is stabilized, and, as a result, highly accurate three-dimensional modeled objects can be obtained.

[Brief Explanation of the Drawings]

[FIG. 1]

A three-dimensional view showing a processing tank portion provided in Practical Embodiment 1 of the present invention.

[FIG. 2]

A side view showing a cross-section of the processing tank for the purpose of explaining the motion of the squeegee in the processing tank provided in Practical Embodiment 1 of the present invention.

[FIG. 3]

A three-dimensional view of the principal portion of the mechanism whereby the squeegee is driven relative to the processing tank provided in Embodiment 1 of the present invention.

[FIG. 4]

A front view of the principal portion of the mechanism whereby the squeegee is driven relative to the processing tank provided in Embodiment 1 of the present invention.

[FIG. 5]

An explanatory diagram showing the operation of the squeegee in the embodiments of the present invention.

[FIG. 6]

An explanatory diagram showing the operation of the squeegee in the embodiments of the present invention.

[FIG. 7]

A side view showing the principal portion of the optical modeling apparatus of Practical Embodiment 2 of the present invention.

[FIG. 8]

A side view showing the principal portion of the optical modeling apparatus of Practical Embodiment 3 of the present invention.

[FIG. 9]

A schematic block diagram showing a prior-art optical modeling apparatus.

[FIG. 10]

A side view showing the principal portion of a prior-art optical modeling apparatus.

[Reference Numerals]

1. Base plate.
2. Three-dimensional modeled object.
3. Liquid resin.
- 3a. Liquid resin surface.
4. Squeegee.
- 4a. Squeegee main body.
- 4b. Squeegee sweeping section.
7. Processing tank.
8. Drive unit.
9. Laser beam excitation unit.
- 10, 14. Laser beam.
11. Scanning unit.
17. Rail.
18. Second stopper.
19. First stopper.
21. Reversing plate.
32. Block.

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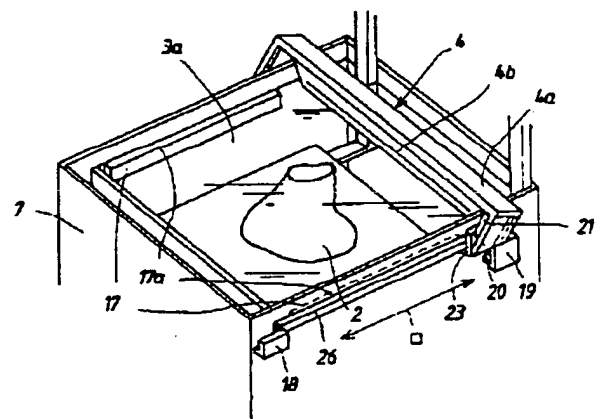
Olympus Optical Co., Ltd

(54) 【発明の名称】 光学的造形装置

(57) 【要約】

【目的】 簡単な機構で、樹脂液面の変化を防止し、平滑な液面を得る。

【構成】 立体造形物 2 をスライスした断面形状データに基づいて、紫外線レーザ光線を加工槽 7 内に収容した光硬化性の樹脂液 3 の表層部に照射する手段と、この紫外線レーザ光線の照射と交互に硬化層上に次液層を導入する手段と、液面 3 a を均す掃取機 4 とを備え、ベースプレート 1 の上面に樹脂液 3 を一層ずつ硬化させて立体造形物を形成する光学的造形装置において、前記掃取機 4 は、前記樹脂液 3 の液面 3 a に沿って移動自在に設けるとともに、掃取機先端面が前記樹脂液 3 の中に入りかつ前記液面 3 a と一致し得るように移動自在に設け、前記先端面と前記液面 3 a とが一致する区間で立体造形物 2 を形成するようにした。



- |            |             |
|------------|-------------|
| 1 ベースプレート  | 17 レール      |
| 2 立体造形物    | 18 第 2 ストップ |
| 3 a 樹脂液面   | 19 第 1 ストップ |
| 4 掃取機      | 21 回転板      |
| 4 a 掃取機本体  |             |
| 4 b 掃取機導引部 |             |
| 7 加工槽      |             |



## 【特許請求の範囲】

【請求項1】 立体造形物をスライスした断面形状データに基づいて、紫外線レーザ光線を加工槽内に収容した光硬化性の樹脂液の表層部に照射する手段と、この紫外線レーザ光線の照射と交互に硬化層上に次液層を導入する手段と、液面を均す掃取機とを備え、ベースプレートの上面に樹脂液を一層ずつ硬化させて立体造形物を形成する光学的造形装置において、前記掃取機は、前記樹脂液の液面に沿って移動自在に設けるとともに、掃取機先端面が前記樹脂液中に入りかつ前記液面と一致し得るよう

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量以上の樹脂液3が流れ込む。ポンプ15による加工槽7への樹脂液3の送り込みは常に一定であるため、樹脂液面3aの位置が変化する。この変化量は、加工槽7内の樹脂液3に沈降配置されたベースプレート1や立体造形物2の体積等により比例するため、ベースプレート1の位置により、樹脂液面3aは変化してくるのである。樹脂液面3aの高さが変化すると、当然スライスデータの層分の厚さが不安定になり、結果精度不良や各層の剥がれが生じ不良となる。

【0010】また、特開平6-285998号公報記載の積層方法では、外槽内に内液層を設置する分、ベースプレート1の昇降により積層する方法よりも、装置全体が大きくなってしまふ欠点がある。

【0011】本発明は、上記従来技術の問題点に鑑みてなされたもので、簡単な機構で、樹脂液面の変化を防止し、平滑な液面を得ることができる光学的造形装置を提供することを目的とする。

【0012】

【課題を解決するための手段】上記目的を達成するために本発明の光学的造形装置では、以下のように構成した。請求項1の発明は、立体造形物をスライスした断面形状データに基づいて、紫外線レーザ光線を加工槽内に収容した光硬化性の樹脂液の表層部に照射する手段と、この紫外線レーザ光線の照射と交互に該硬化層上に次液層を導入する手段と、液面を均す掃取機とを備え、ベースプレートの上面に樹脂液を一層ずつ硬化させて立体造形物を形成する光学的造形装置において、前記掃取機は、前記樹脂液の液面に沿って移動自在に設けるとともに、掃取機先端部が前記樹脂液中に入りかつ前記液面と一致し得るように移動自在に設け、前記先端部と前記液面とが一致する区間で立体造形物を形成するようにした。

【0013】また、請求項2の発明は、請求項1の構成にあって、前記掃取機先端部が液面と一致する区間には、掃取機先端部を案内するレールを樹脂液の液面に対して平行に設置した。この場合において、平行なレールは、樹脂液の液面に近い位置、すなわち加工槽の内側に掃取機の動く方向に対して垂直方向に設置し、レール上面を液面の位置に合わせるのがよい。

【0014】さらに、請求項3の発明は、請求項2の構成にあって、前記レールに、上下位置調整可能な機構を設けた。この場合において、上下位置調整機構は、レールが液面の高さおよび平行度に対処できるようにレールの両端付近2箇所を設置するのがよい。

【0015】

【作用】請求項1の構成にあっては、最初に、掃取機先端部が樹脂液の中に入る区間で樹脂液の大きな波を起こし、次の区間では、液面の表面を掃引する。すなわち、掃取機の掃引だけで樹脂液の液層と樹脂液面の均しか行うことが可能となり、樹脂液積層時間の短縮になる。ま

た、ベースプレートと立体造形物の昇降が抑えられるため、樹脂液面の安定にもなり立体造形物の精度向上と不良削減になる。

【0016】請求項2の構成にあっては、請求項1の動作を起こすべく、掃取機動作中の最初のレールがない区間では、掃取機の先端が樹脂液中に入り、次のレール設置区間は液面を均すことが可能となる。

【0017】請求項3の構成にあっては、レールに、例えば前記レール両端付近2箇所に、上下位置調整機構を設置することにより、レール上下位置を調整するとともに、液面に対しての平行度も調整することができる。よって、液面位置の変化等に素早く対応できる。

【0018】

【実施例】以下、添付図面を参照して本発明に係る光学的造形装置の実施例を説明する。なお、本発明は、光学的造形装置における樹脂液の積層方法についての発明であるので、その他の光学的造形装置の原理や装置構成は、従来技術の説明で述べた内容と同じである。よって、以下の実施例では光学的造形装置の原理や装置構成の説明を省き、樹脂液の積層方法についてのみ説明を行う。また、図9と同一構成部分については同一符号を付すものとする。

【0019】【実施例1】本発明の実施例1を図1～図6に基づいて説明する。図1は、本実施例の光学的造形装置における加工槽部分を示す斜視図（後述のモータは図示省略）、図2は図1の加工槽における掃取機の移動状態を説明するため加工槽を断面にして示す側面図、図3および図4は加工槽に対する掃取機の駆動機構を説明するための要部の斜視図および正面図、図5および図6は掃取機の動作を示す説明図である。

【0020】図1において、掃取機4は、加工槽7の上部を跨がるように長手方向部分の両端部を屈曲してコの字形をなした掃取機本体部4aと、この本体部4aの長手方向部分の下面側に配設される掃取機掃引部4bとを有し、加工槽7の上部で矢印口4cの方向に移動自在に設けられている。

【0021】掃取機本体部4aは、長手方向部分が加工槽7の上部に位置するとともに、その両端部が加工槽7の外側面に位置するように配置されており、両端部の端面は、図1および図3に示すように、本体部4aの長手方向部分（水平部分）に対して、傾斜した傾斜面20を有している。また、本体部4aのコの字形の両端部のそれぞれの内側（加工槽7側）には、前記傾斜面20の傾斜方向とは逆向きに傾斜面22を下面に形成した反転板21がそれぞれ取り付けられている。

【0022】さらに、本体部4aのコの字形の一方の端部に設けた前記反転板21の内側（加工槽7側）には、図1、図3および図4に示すように、L字形の案内板23が取り付けられている。案内板23を配置した前記本体部4aの端部の側面にはモータ24が取り付けられて

おり、このモータ24の駆動軸24aは、図4に示すように、本体部4aの端部、反転板21および案内板23を貫通し、その先端にピニオン25が取り付けられている。このピニオン25は加工槽7の外側面に取り付けたラック26と係合するとともに、ラック26の下面は前記L字形の案内板23と摺接する構成となっている。従って、モータ24の正転、逆転によって、掃取機4は図1に示す矢印ロの方向で進退動するようになっている。

【0023】なお、本体部4aのコの字形の他方の端部に設けた反転板21の内側は直接に加工槽7の外側面と摺接するようにしてもよいし、また、前記一方の端部の如く、加工槽7の外側面（不図示）に取り付けたラック（不図示）と摺接する案内板（不図示）を設けても良い。

【0024】一方、掃取機本体部4aの長手方向部分（水平部分）の下面側に配設された前記掃取機掃引部4bは、図2および図4に示すように、前記本体部4aの両端部の内側にそれぞれ水平方向に植設した支持棒27によって揺動自在に支持されるとともに、この掃引部4bは、本体部4aの下面に取り付けられたバネ28（図2参照）によって付勢されている。

【0025】次に、樹脂液3を収容する加工槽7について説明する。図1において、加工槽7の内側面の両サイドには、掃取機掃引部4bの先端面と当接し該先端面を案内するレール17がそれぞれ設置されている。このレール17の上端面17aは、樹脂液面3aと同一高さに調整されている。

【0026】また、図1において、加工槽7の外側面には、前述のようにラック26が取り付けられており、このラック26のそれぞれの端部には、第1ストッパー19と第2ストッパー18が配置されている。この第1、第2ストッパー19、18は、加工槽7の対向する両外側面にそれぞれ設けられており、第1ストッパー19同士、第2ストッパー18同士はそれぞれ同じ位置に配置されている。第1ストッパー19は、前記掃取機本体部4aの端部の傾斜面20に当接する位置（高さ）に設けられ、また、第2ストッパー18は、掃取機本体部4aの端部の内側に取り付けた反転板21の傾斜面22に当接する位置（高さ）に設けられている。（従って、第1ストッパー19と第2ストッパー18とは、加工槽7の側面における高さが異なっている。）。さらに、この第1、第2のストッパー19、18は、前記傾斜面20、21と当接する部位が、図2に示すように、樹脂液面3aに対して高い位置となるように設けられている。

【0027】次に、掃取機4を加工槽7に対して移動させるときの状態について説明する。図1における掃取機4は、その本体部4aの傾斜面20が第1ストッパー19の上面に摺接した状態になっている。この状態から、図3および図4に示すモータ24の駆動により、ピニオン25が回転し、ラック26との噛み合いにより、掃取

機4は第2ストッパー18に向けて図2の矢印ハの方向に移動する。この際、図2に示す、D位置からC位置に向けて移動するが、本体部4aの傾斜面20が第1ストッパー19の上面に摺接した状態では、掃引部4bはバネ28の付勢により、その先端が樹脂液3の液中に入り込んでいる。次いで、本体部4aの移動により掃引部4bの先端は、加工槽7の両内側面に設けたレール17の上端面17a上に載せられるとともに、バネ28によって押圧され、強制的にレール17の上端面17aと同一高さ、すなわち、樹脂液面3aと同一高さとなって、C位置に向けてBの区間で掃引される。

【0028】そして、B区間の最終側に掃引部4bが達したときに、樹脂液面3aが均されて、所望の形状の樹脂層の硬化が行われる。樹脂の硬化が完了したら、ベースプレート1を駆動装置8により立体造形物2の一層分だけ、レール17の上端面17aより低くした位置に停止させる。そして、ポンプ（不図示）から所定量の樹脂液を加工槽7内に供給する。

【0029】次いで、C位置へ向かうときに、第2ストッパー18に反転板21の傾斜面22が当接しつつ移動するので、コ字形の本体部4aは、その向きを変える。すなわち、図5で示すように、矢印の向きに掃取機4が移動すると、反転板21の傾斜面22が第2ストッパー18に当接し、さらに、掃取機4が移動すると掃取機本体部4aの倒れ方向を変え、反転板21の傾斜面22が第2ストッパー18の上面に摺接する。このC位置で、図2に示すように、掃引部4bがバネ28によって付勢されるが、掃取機本体部4aの上記倒れにより掃引部4bの先端は液面から離れた状態になっている。

【0030】次いで、モータ24の逆転により、掃取機4は逆方向に、すなわち図2に示す矢印ニの方向に移動し、このときの本体部4aと反転板21の状態は図6に示されるようになる。そして、掃取機4がB区間を通過し、A区間に達したときに、掃取機本体部4aの傾斜面20が第1ストッパー19に当接しつつ移動するので、図6に示されるように、本体部4aの倒れ方向を変え、傾斜面20が第1ストッパー19の上面に摺接するとともに、掃引部4bの先端が液中に入り込む。

【0031】このままの状態では掃取機4が図2の矢印ハの方向に移動し、掃取機掃引部4bがA区間を移動すると、樹脂液面3aには大きめの波3bが掃取機掃引部4bにより起こされる。この後、掃取機4がB区間を移動すると、掃取機掃引部4bがレール17の上端面17aにより強制的に位置設定され、A区間でできた波3bを均し、ベースプレート1上の立体造形物2の上面と樹脂液面3aとの間隔を一定、すなわち、立体造形物2の上面に積層する樹脂液3の厚さを一定にし、掃取機4がC地点に来たとき、第1ストッパー19により、掃取機4の向きが変えられて止まるのである。

【0032】本実施例によれば、掃取機4の掃引によ

り、立体造形物2の上面に対する樹脂液3の積層と樹脂液面3aの均しを同時に行うことができ、ベースプレート1の昇降を最小限に抑えることができるので、立体造形物2の造形時間を短縮できるとともに、樹脂液面3aの変動を抑え込み、精度の高い立体造形物2をつくることができる。

【0033】[実施例2] 次に、本発明の実施例2を図7に基づいて説明する。図7は本実施例の光学的造形装置の要部を示す側面図である。本実施例は、掃取機掃引部4bの先端を強制的に位置設定するレール17に上下位置と平行度の調整機構を備えて構成されている。すなわち、レール17の長手方向の両サイド下部に相当する加工槽7の内側面に基台30を固定し、この基台30上にネジ31を介してレール17を配置して構成したもので、ネジ31を回動することにより、レール17の上記調整を行うようになっている。その他の構成は実施例1と同様であり、その説明は省略する。

【0034】本実施例によれば、レール17の高さや平行度を簡単に調節できるようになっているため、なんらかの理由で樹脂液面や掃取機先端面が変化しても、素早くレール位置を調節することにより、ベストの状態で造形を行うことができる。

【0035】[実施例3] 次に、本発明の実施例3を図8に基づいて説明する。図8は本実施例の光学的造形装置の要部を示す斜視図である。本実施例は、実施例1に設けた長いレール17の代えて、短いレールを複数個連接して前記長いレールを形成すべく、数個のブロック32を設置して構成されている。ブロック32は、加工槽7の内側面に固定した磁気性を持つ基台33の上に磁力により着けてあり、それぞれ脱着可能となっている。その他の構成は実施例と同様であり、その説明は省略する。

【0036】本実施例によれば、それぞれのブロック32の脱着により、掃取機4の先端が樹脂液3の中に入る区間(図2におけるA区間)と樹脂液面3aを均す区間(図2におけるB区間)を自由に設定できるため、積層する樹脂液3の量や位置を調整することができ、より効果的で積層不良のない光学的造形物の作成が可能となる。

【0037】本発明は、上記目的を達成するために、以下のように構成してもよい。前記掃取機先端面が液面と一致する区間において、掃取機先端面を案内するレールを樹脂液の液面に対して平行に設置したレールは、脱着可能な数個のブロックで構成してもよい。上記構成によれば、掃取機先端面が液中に入る区間と液面と一致する区間を任意に調節することができる。

【0038】また、前記数個のブロックは、加工槽7に固定した基台に磁力により脱着可能に設けて構成してもよい。上記構成によれば、レールを形成するブロックの脱着を素早く行うことができる。

【0039】

【発明の効果】以上説明したように、本発明の光学的造形装置によれば、樹脂液面を掃取機で掃引する時に、掃取機先端部が樹脂液中に入る区間をへて樹脂液面上を移動する区間に至るため、樹脂液の積層と樹脂液面の均しを一度に行うことができる。よって、ベースプレートの昇降による樹脂液の積層が省かれるので、造形時間の短縮となる。また、ベースプレートの昇降が最小限に抑えられることにより、樹脂液の循環が規則正しくなるので、樹脂液面の位置が安定し、結果、高精度の立体造形物を得ることができる。

【図面の簡単な説明】

【図1】本発明の実施例1に備えた加工槽部分を示す斜視図である。

【図2】本発明の実施例1に備えた加工槽に対する掃取機の移動状態を説明するため加工槽を断面にして示す側面図である。

【図3】本発明の実施例1に備えた加工槽に対する掃取機の駆動機構の要部を示す斜視図である。

【図4】本発明の実施例1に備えた加工槽に対する掃取機の駆動機構の要部を示す正面図である。

【図5】本発明の各実施例における掃取機の動作を示す説明図である。

【図6】本発明の各実施例における掃取機の動作を示す説明図である。

【図7】本発明の実施例2の光学的造形装置の要部を示す側面図である。

【図8】本発明の実施例3の光学的造形装置の要部を示す側面図である。

【図9】従来の光学的造形装置を示す概略構成図である。

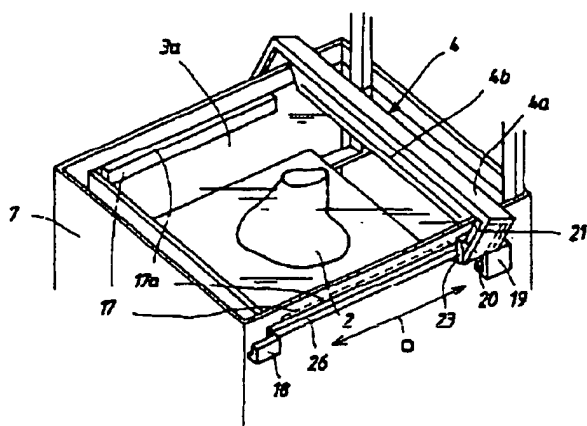
【図10】従来の光学的造形装置の要部を示す側面図である。

【符号の説明】

- 1 ベースプレート
- 2 立体造形物
- 3 樹脂液
- 3a 樹脂液面
- 4 掃取機
- 4a 掃取機本体
- 4b 掃取機掃引部
- 7 加工槽
- 8 駆動装置
- 9 レーザ光励起装置
- 10, 14 レーザ光
- 11 スキャニング装置
- 17 レール
- 18 第2ストッパー
- 19 第1ストッパー
- 21 反転板

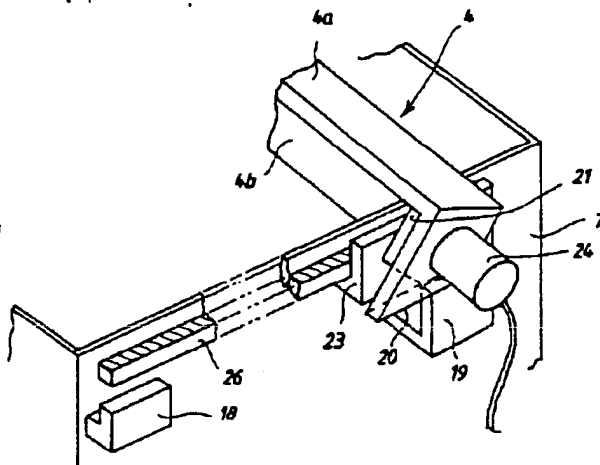
## 32 ブロック

【図1】

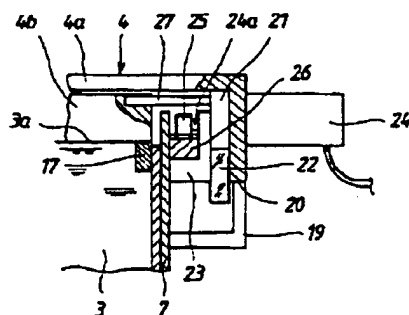


- |            |            |
|------------|------------|
| 1 ベースプレート  | 17 レール     |
| 2 立体造形物    | 18 第2ストッパー |
| 3a 側面図     | 19 第1ストッパー |
| 4 揚取機      | 21 反転板     |
| 4a 揚取機本体   |            |
| 4b 揚取機ガイド部 |            |
| 7 加工槽      |            |

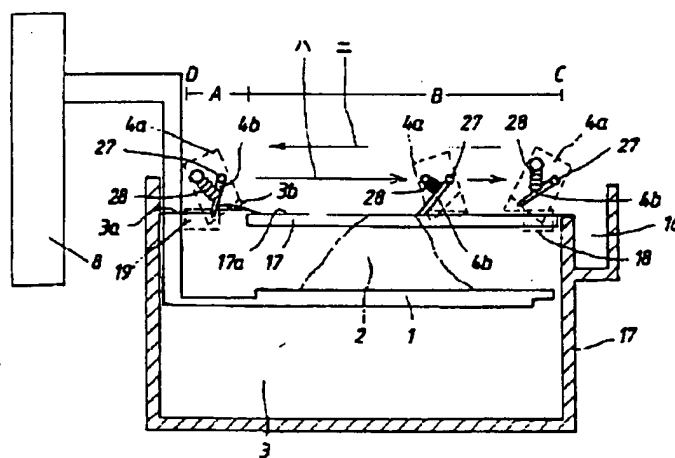
【図3】



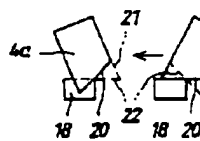
【図4】



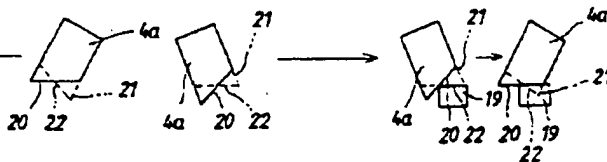
【図2】



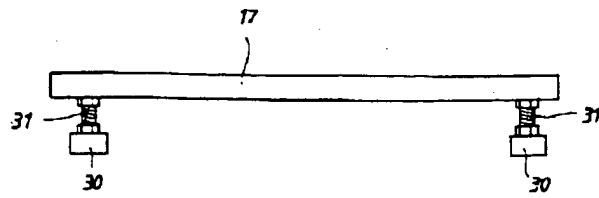
【図5】



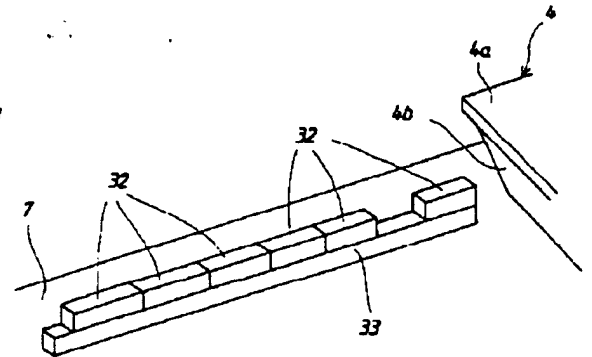
【図6】



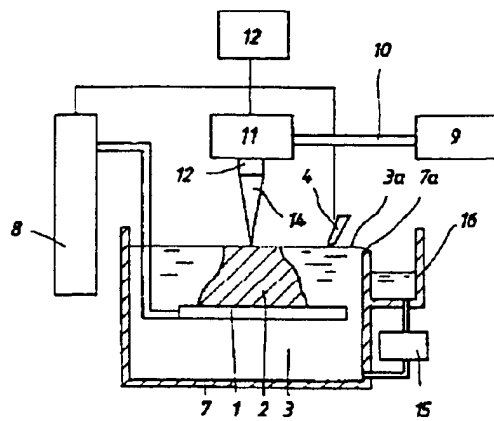
【図7】



【図8】



【図9】



【図10】

